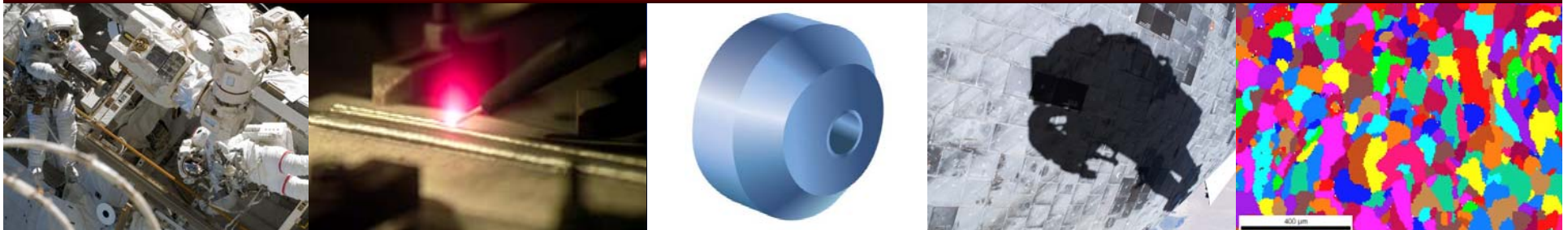




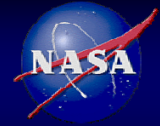
# Innovative Forming of Advanced Metallics

John Wagner and Marcia Domack  
NASA- Langley Research Center  
Hampton, Virginia

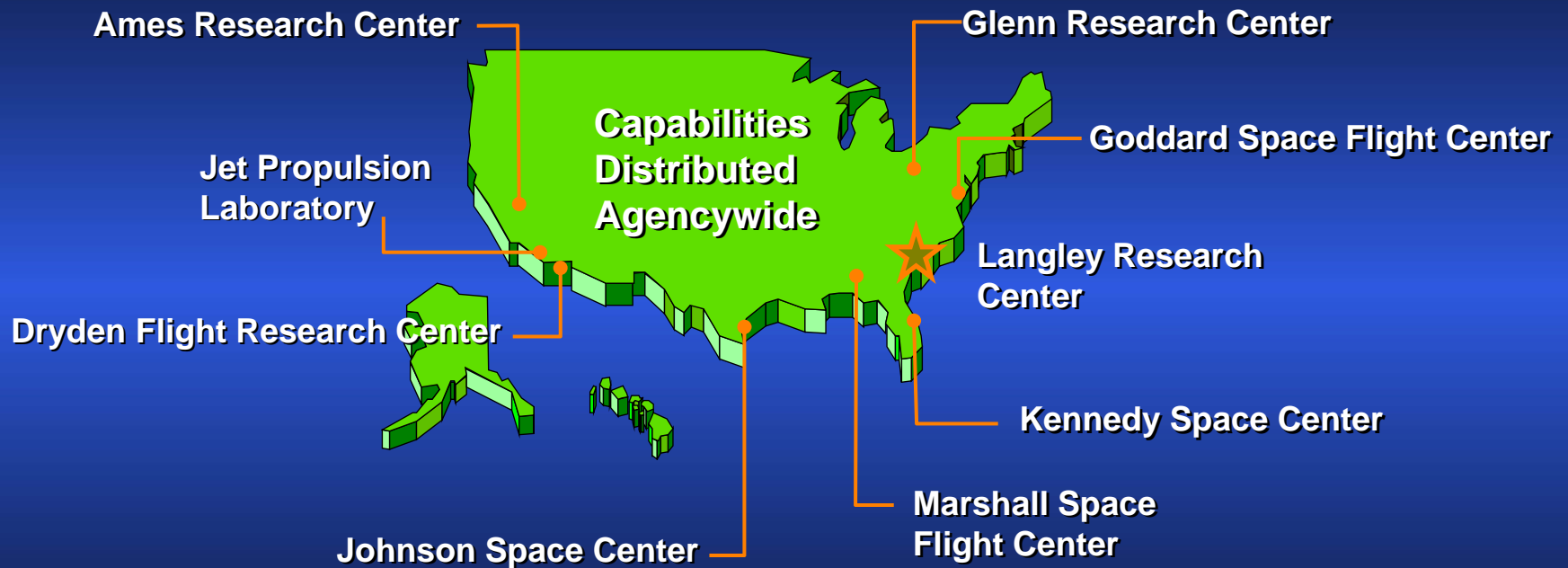
January 2015



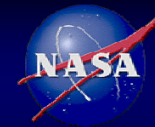
# NASA Field Centers



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# NASA Langley Research Center



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*Delivering on Today's Commitments...*

*Creating Tomorrow's Opportunities.*



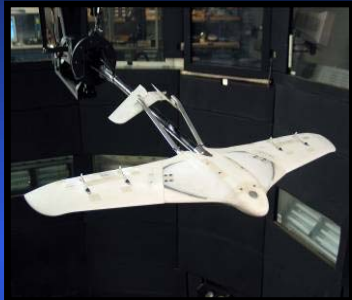
# NASA Langley Core Competencies



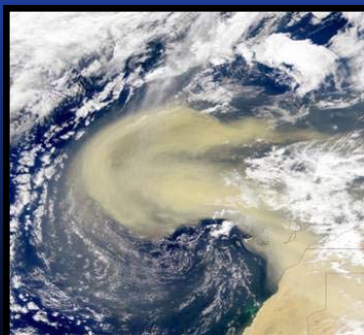
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## Aerosciences

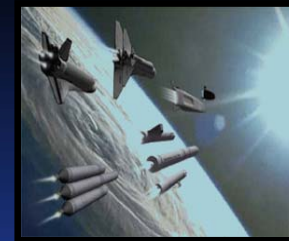
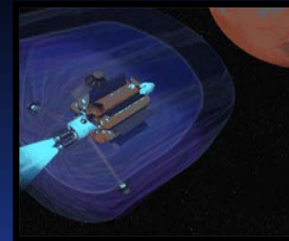
Research for Flight in All Atmospheres



Characterization of all Atmospheres  
(Lasers & LIDAR)



## Aerospace Systems Analysis



Entry, Descent & Landing



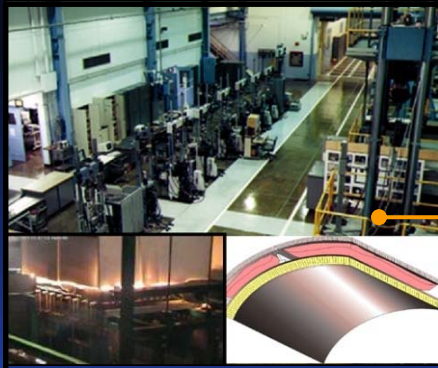
Materials & Structures



# Materials & Structures



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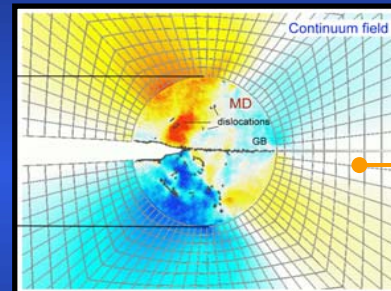


**Durability &  
Damage Tolerance**

**Materials  
Synthesis  
& Processing**



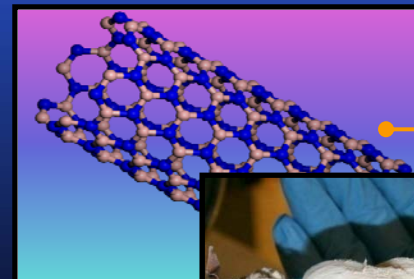
**Impact & Landing  
Dynamics**



**Computational  
Materials  
Design**



**Structural  
Concepts**



**Nanostructured  
Materials**



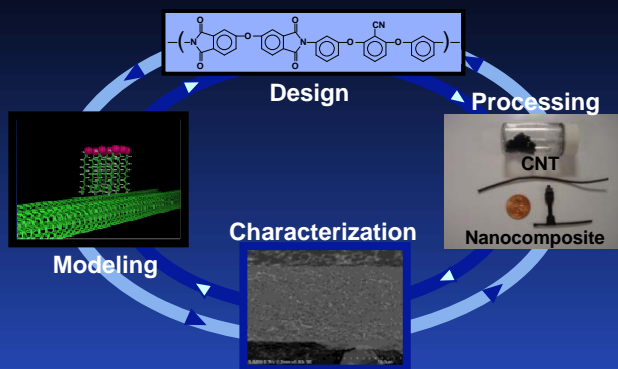


# Advanced Materials and Processing Branch

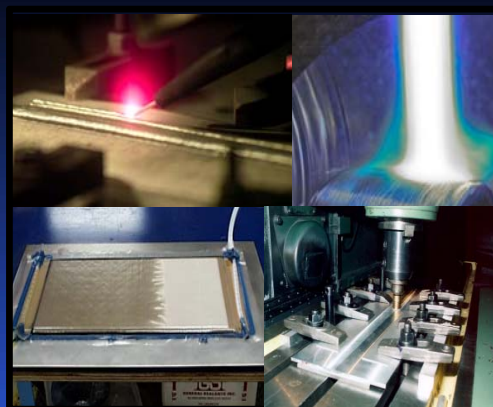


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## Materials Design



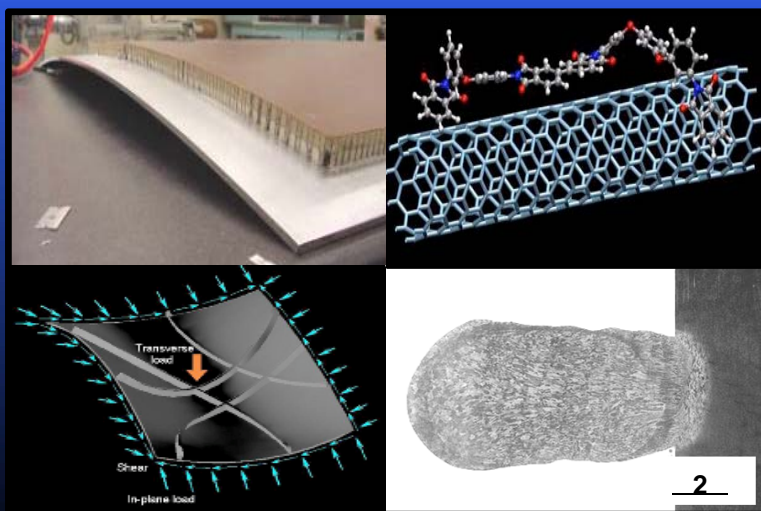
## Innovative Materials Processing



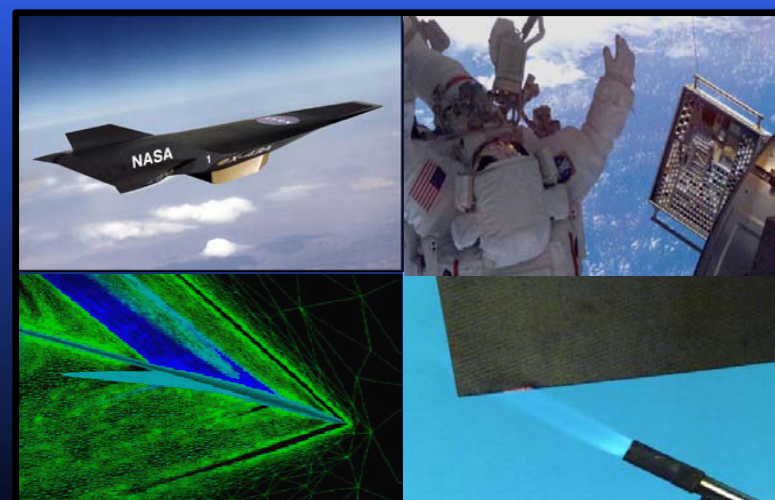
## Materials Testing



## Advanced Material Systems



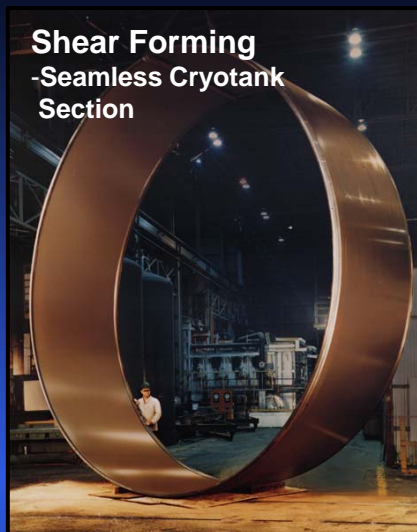
## Materials for Extreme Environments



# Near Net Shape Manufacturing of Al & Al-Li Alloys for Launch Vehicle Structures



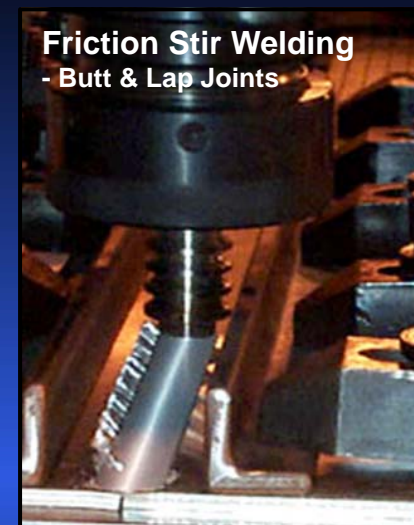
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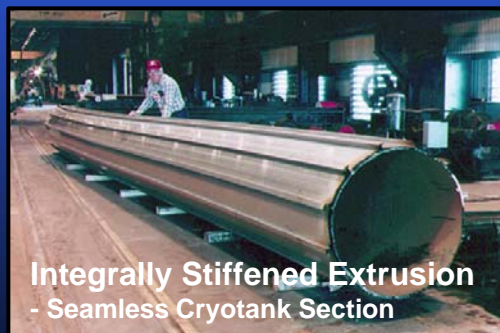
**Shear Forming**  
- Seamless Cryotank Section



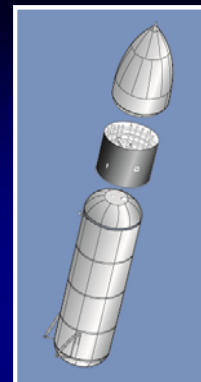
**Roll Forging**  
- Adapter Rings



**Friction Stir Welding**  
- Butt & Lap Joints



**Integrally Stiffened Extrusion**  
- Seamless Cryotank Section



- BENEFITS**
- Reduced Material Scrap Rate
  - Lower Cost, Enhanced Performance
  - Increased Reliability
  - Reduced Part Count
  - Reduced Assembly Time



**Spin Forming**  
- Cryotank Dome



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# Motivation and Background

- Majority of launch vehicle cryotanks and dry bay structures fabricated using Al alloys and fabrication technologies developed in the 1950's
- Opportunities exist for utilizing new and revolutionary metal forming techniques to significantly impact cost, weight and safety
- Near net shape forming has the potential to reduce metal scrap rate (machining chips) in the production of launch vehicle structures from the current rate of 90% to 5%
- Al- Li alloys are ~ 10 % lighter and exhibit higher strength and modulus than current 2219 Al cryotank material
- Increased safety and reduced weight through the elimination of welds (defects) and weld land (ET has 30,000 inches of welds)



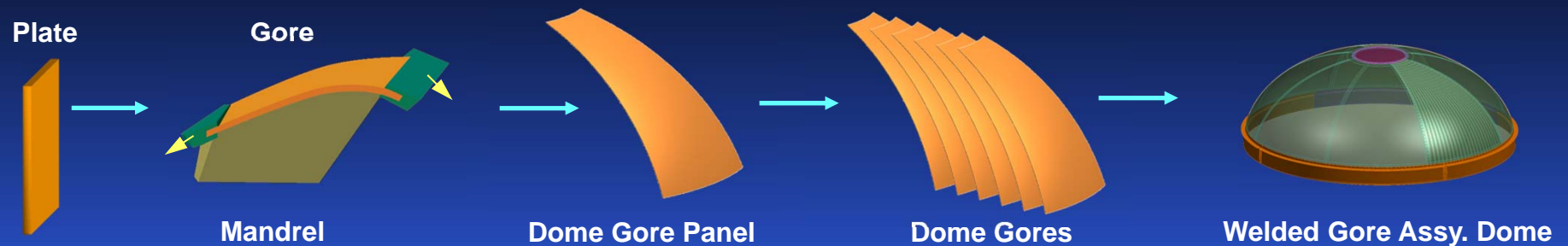
# Cryogenic Tank Dome Manufacturing

## Multi-Piece Welded Gore Construction vs. Spin Forming

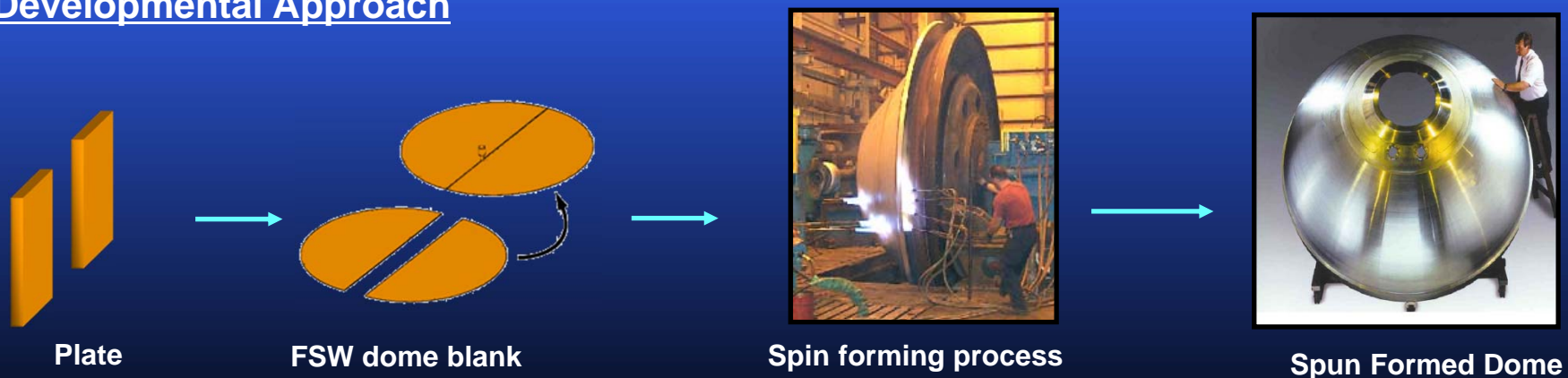


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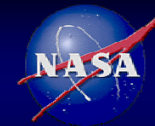
### Traditional Approach



### Developmental Approach



# Inspection of Partially Formed Dome



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# Adaptable/Flexible Tooling for Fabricating Space Structures



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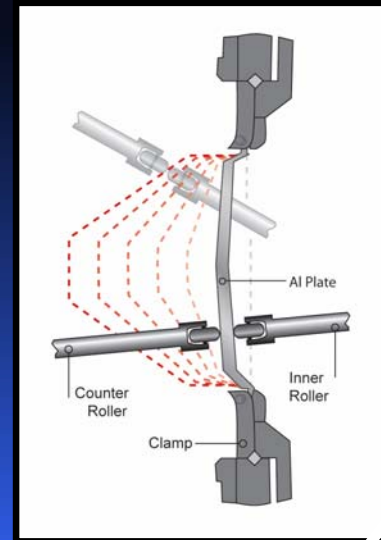
Aluminum  
Forming

Successful with  
Aluminum



As-formed, no machining  
0.6 m dia.

Demonstrate with  
complex geometry



Successful Aluminum  
Subscale Crew Module

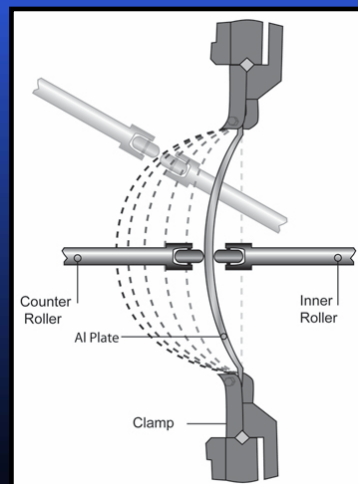


Commercially Produced  
Titanium Dome



As-formed, no machining  
~2m dia.

Counter Roller Process



Scale up to Full Size  
Component

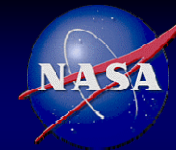


John.A.Wagner@nasa.gov

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# Novel Fabrication of Integrally Stiffened Cylinders for Improved Safety and Reliability of Metallic Cryotanks



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Al-Li  
Forming



Commercially produced  
steel clutch housing



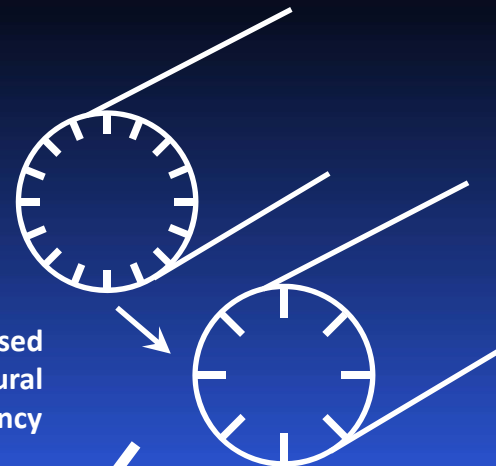
As-formed, No machining,  
0.3m dia.

Successful Forming of  
Al-Li 2195



As-formed, No machining,  
~0.3m dia.

Scale-up to ~1m dia.,  
optimize stiffener  
height/spacing

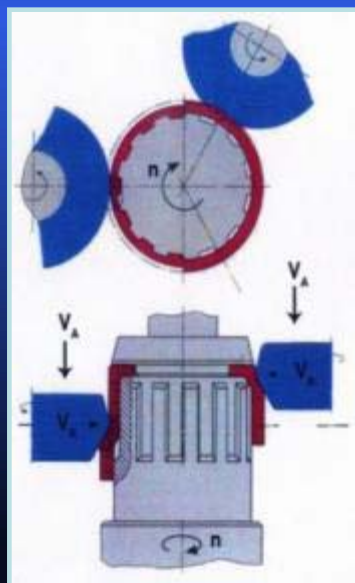


Increased  
structural  
efficiency

Scale Up to  
Full Size Barrel



External Tank LH<sub>2</sub> Barrel Assembly



Spin/flow forming process  
for fabrication of integrally  
stiffened cylinders

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# Langley Research Center ----

---- from the beginning!



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*2017 will be  
NASA Langley  
Research  
Center's 100<sup>th</sup>  
Anniversary*

